

Health Effects in Army Gulf War Veterans Possibly Exposed to Chemical Munitions Destruction at Khamisiyah, Iraq: Part II. Morbidity Associated with Notification of Potential Exposure

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The purpose of this study was to examine the association of notification of potential exposure to chemical warfare agents in the 1991 Gulf War with subsequent self-reported morbidity. The study sample included 1,056 deployed Army Gulf War veterans who responded to the 1995 National Health Survey of Gulf War Era Veterans and who were resurveyed in 2000. One-half of the subjects had been notified of potential exposure to chemical warfare agents and one-half had not. Comparing notified and non-notified subjects, there were no statistically significant differences with respect to bed days, activity limitations, clinic visits, or hospital visits. Among 71 self-reported medical conditions and symptoms, there were 5 statistically significant differences, 4 of which were for lower rates of illness among notified subjects. Our findings contradict the prevailing notion that perceived exposure to chemical warfare agents should be considered an important cause of morbidity among Gulf War veterans.

Introduction

On March 4 and 10, 1991, combat engineer and explosive ordnance disposal units of the U.S. Army XVIII Corps (Airborne) destroyed two large caches of rockets at the Khamisiyah ammunition supply point, ~350 km southeast of Baghdad, Iraq. In a companion article,¹ we examined the association between possible exposure to the chemical warfare agents sarin and cyclosarin and self-reported morbidity. After the announcement of possible exposure to chemical munitions, the Department of Defense (DoD) undertook efforts not only to determine who was potentially exposed to nerve agents but also to notify military service personnel of their potential exposure.

In this article, we report on the association between notification of potential exposure and self-reported health using data from the National Health Survey of Gulf War Era Veterans. Our study of the effects of notification takes particular advantage of the fact that the National Health Survey of Gulf War Era Veterans collected initial data in 1995, before the commencement of notification activities. By readministering the identical health

survey in 2000, we were thus able to examine postnotification self-reported health, having in hand the identical data on pre-notification self-reported health.

Methods

Determining Notification of Potential Exposure

There were three outreach efforts by the DoD, of which the first two are relevant to this study. On the basis of available information and discussions with experts before extensive modeling efforts, the DoD sent letters and surveys in October 1996 to ~20,000 troops known to have been within a 50-km radius of Khamisiyah between March 1 and March 15, 1991. A 25-km zone was chosen as a conservative estimate of the distance at which the first noticeable effects of chemical agents would have been seen and was then doubled to a 50-km zone as an added safety measure, to ensure inclusion of all U.S. forces in transit through the Khamisiyah area. The letter informed individual service members that chemical munitions might have been destroyed at Khamisiyah. The response rate for this mailing was approximately 37% ($n = 7,400$ surveys returned). Although this effort did not specifically mention potential exposure to chemical warfare agents, we refer to it as the "50-km notification."²

On the basis of the results of the 1997 plume model,² the DoD subsequently mailed ~99,000 letters of notification, informing troops of their possible exposure to low levels of chemical warfare agents. At the same time, letters were sent to the individuals (~10,000) who had been contacted in the initial wave of notifications in October 1996, informing them that, in all likelihood, they had not been exposed to chemical warfare agents. We refer to this second notification effort as the "1997 plume notification." We counted as "notified" any veteran who received a 50-km notification letter or a 1997 plume notification letter.

The modeling efforts continued with a new plume, the "2000 plume model," which included several improvements (see Ref. ¹ for details). On the basis of the results of this model, a third set of letters was sent in December 2000 to notify individuals of their potential exposure to chemical warfare agents. However, because our resurvey was completed before the third set of notification letters was sent, notification status in this study does not take into account the third set of letters. Because there were two notification efforts, separated in time, and the follow-up time from the last notification was relatively short, we did not examine the effect of notification on mortality rates.

Sample Composition

Samples of 15,000 Gulf War veterans and 15,000 non-Gulf War veterans were originally used to conduct the National

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Health Survey of Gulf War Era Veterans. These samples were taken from the Defense Manpower Data Center cohorts described above, using a stratified sampling scheme. Both deployed and nondeployed samples were stratified with respect to gender and unit component (active duty, Reserve, or National Guard), with oversampling of women and non-active duty components. The original sample contained 20% women, 25% National Guard personnel, and 33% reservists; the corresponding proportions among all deployed personnel were 7%, 7%, and 10%, respectively. The response rate for the original health survey was 70%.

For the present study, a subsample of 1,200 respondents to the National Health Survey was selected. This random subsample was originally chosen to contain equal numbers of exposed and nonexposed Army veterans, as well as equal numbers of notified and non-notified Army veterans. However, the inadvertent inclusion of non-Army subjects meant that the final sample numbered only 1,056 subjects, of whom 756 (72%) provided responses. The response rate for notified subjects in the resurvey was 73% (438 of 600 subjects), and the response rate for non-notified subjects was 70% (318 of 456 subjects). This project was submitted for institutional review board review, and approval was obtained from both the Department of Veterans Affairs and the National Academy of Sciences.

Health Outcomes

The health outcomes were the same as those in the original health survey (see Ref. ³ for details). Briefly, the outcomes included the following: number of bed days, activity limitations attributable to health, number of doctor visits in the past 12 months, number of hospitalizations in the past 12 months, overall health status (e.g., good or fair), selected medical conditions, selected symptoms, birth defects (yes/no), life events scale results, and post-traumatic stress disorder scale results.

Statistical Methods

Because we used a multiple-stage survey design involving responses to the initial health survey and the resurvey, we chose not to weight the data for nonresponses. Simple prevalence rates for notified and non-notified subjects were compared with the χ^2 test, and the Cochran-Mantel-Haenszel test was used to compute adjusted risk ratios comparing notified subjects with non-notified subjects. We have not shown data for outcomes for which any table cell had <10 subjects, corresponding approximately to outcomes with a prevalence rate of <3%.

Risks ratios were adjusted for exposure status, initial health survey response, age in 1991 (<30 years versus ≥ 30 years), gender, race (Caucasian or Hispanic versus all other), marital status (single versus all other), rank (enlisted versus officer or warrant officer), and Army active duty versus Army Reserve or National Guard service. These adjustment factors were chosen based on their potential association with health outcomes. All except the first two factors were used to compute a propensity score,⁴ which, divided into quintiles, was used to adjust for these factors in Cochran-Mantel-Haenszel analyses. We examined data for individual outcomes according to exposure and notification status and found no substantial interactions. Therefore, we subsequently analyzed only the effects of notification on health outcomes, adjusted for exposure status.

No adjustments for item nonresponse were made, although we compared respondents with nonrespondents to the second questionnaire, looking at demographic data and initial outcomes. An earlier analysis of the characteristics of respondents and nonrespondents to the initial health survey (not limited to Army personnel) showed nonrespondents to be, on average, younger, unmarried, non-Caucasian, and of enlisted rank; gender, branch of service, and unit component (active duty, National Guard, or Reserve) status were not associated with response status.³ In addition, certain items, such as reported exposures while in the Gulf, should not have changed between the initial health survey and the resurvey. Data comparing initial survey and resurvey responses for these items thus provide information on potential reporting biases or lack of such biases.

Results

Table I shows selected characteristics of respondents and nonrespondents. In general, the distributions of characteristics among respondents and nonrespondents were similar. Respondents were, however, proportionally more female, Caucasian, and married, and there were proportionally more officers and soldiers with National Guard or Reserve status. There was a slightly larger proportion of notified subjects among respondents than among nonrespondents.

Table II addresses the issue of data quality by comparing items that should reasonably have been reported the same way in the initial health survey and in the resurvey. The items pertained to self-reported exposures while in the Gulf, and we tabulated the proportions of responses that were concordant

TABLE I
PERCENT DISTRIBUTION OF SELECTED CHARACTERISTICS OF
RESPONDENTS (N = 756) AND NONRESPONDENTS (N = 300)

Characteristics	Respondents (n = 756)	Nonrespondents (n = 300)
Mean age in 1991 (years)	31.5	28.9
Gender (%)		
Male	72.2	83.3
Female	27.8	16.7
Race (%)		
Caucasian	75.5	69.7
African American	17.9	22.7
Other	6.6	7.6
Marital status (%)		
Married	54.4	48.3
Single	39.3	47.0
Other	6.3	4.6
Rank (%)		
Enlisted	84.8	89.3
Officer	13.1	10.3
Warrant Officer	2.1	0.3
Unit component (%)		
Active duty	27.4	39.7
National Guard	38.9	31.0
Reserve	33.7	29.3
Exposure notification status (%)		
Notified	57.9	54.0
Not notified	42.1	46.0

TABLE II
COMPARISON OF INITIAL AND RESURVEY RESPONSES FOR SELECTED ITEMS: PROPORTIONS OF RESPONSES THAT WERE CONCORDANT AND K STATISTICS, ACCORDING TO NOTIFICATION STATUS

Exposure while in Gulf Region	Notification Status			
	Non-Notified		Notified	
	Percent Agreement	κ (95% CI)	Percent Agreement	κ (95% CI)
Smoke from oil well fires	89.5	0.71 (0.62–0.81)	90.3	0.72 (0.64–0.80)
Petrochemical fumes	91.3	0.53 (0.38–0.69)	92.7	0.50 (0.36–0.65)
Burning trash/feces	89.2	0.68 (0.57–0.78)	90.0	0.58 (0.47–0.69)
Skin exposure to diesel/petrochemical fuel	75.3	0.49 (0.39–0.59)	80.1	0.57 (0.49–0.65)
CARC paint	83.2	0.54 (0.43–0.66)	83.5	0.64 (0.56–0.72)
Other paints, solvents, petrochemicals	74.5	0.40 (0.29–0.52)	76.4	0.50 (0.41–0.58)
Depleted uranium	90.5	0.54 (0.39–0.70)	86.1	0.55 (0.45–0.65)
Personal pesticides (e.g., flea collars)	73.0	0.44 (0.34–0.55)	76.1	0.49 (0.40–0.57)
Nerve gas	87.3	0.39 (0.23–0.56)	81.4	0.36 (0.24–0.47)
Mustard gas or blistering agent	90.8	–0.05 (–0.07 to –0.02) ^a	90.3	0.37 (0.22–0.53)
Wore chemical protective gear (other than for training) or heard chemical alarms	92.0	0.65 (0.52–0.78)	85.9	0.44 (0.32–0.56)
Involved in direct combat duty	84.4	0.55 (0.43–0.67) ^a	88.7	0.76 (0.69–0.82)
Witnessed any deaths	82.2	0.56 (0.45–0.66)	85.4	0.68 (0.61–0.75)
Suffered sexual assault	99.0	0.40 (–0.15 to 0.94)	99.5	0.50 (–0.10 to 1.10)
SCUD missile explosion within 1 mile	87.4	0.73 (0.65–0.81)	86.9	0.73 (0.67–0.80)

CARC, chemical agent-resistant compound; CI, confidence interval.

^a Statistically significant difference between κ values for notified and not notified.

(survey and resurvey responses were the same), according to notification status. We noted that, with some exceptions, initial survey and resurvey responses agreed 85 to 95% of the time and κ values were ≥ 0.50 , indicating reasonable agreement. In general, where there were differences in reporting, the rate of self-reported exposure was higher in the resurvey. More importantly, κ values for notified and non-notified subjects were the same for all except involvement in direct combat duty and exposure to mustard gas or blistering agent (with higher κ values for notified subjects).

Table III shows demographic data for non-notified and notified respondents. The non-notified subjects were significantly older, more likely to be female, more likely to be married, and more likely to have been in the National Guard or Reserves; there was no difference in race or rank between the non-notified and notified subjects.

Table IV shows data on the baseline prevalence rates from the initial health survey for bed days, activity limitations, clinic visits, hospitalization, and general health status, all unadjusted for covariates. Despite the demographic differences between non-notified and notified subjects, we noted no statistically significant differences between the non-notified and notified subjects in these crude rates. Tables V and VI display similar baseline data for medical conditions and symptoms, respectively. In Table VI, only excessive fatigue showed a statistically significant difference in baseline prevalence between non-notified and notified subjects, with a higher rate among non-notified subjects.

Tables VII, VIII, and IX contain estimates of the adjusted risk ratios for the association of various health outcomes in the resurvey with notification status. Risk ratios were adjusted for initial response, exposure status, and propensity score, including age, gender, race, marital status, rank, and type of service (active duty, National Guard, or Reserve). The Hosmer-Lem-

TABLE III
PERCENT DISTRIBUTION OF SELECTED CHARACTERISTICS OF NON-NOTIFIED AND NOTIFIED RESPONDENTS

Characteristics	Distribution (%)	
	Non-notified (n = 310)	Notified (n = 446)
Age in 1991		
<30 years	42.9 ^a	57.6
≥ 30 years	57.1	42.4
Gender		
Male	74.2	79.4
Female	25.8	20.7
Race		
Caucasian or Hispanic	81.3	78.3
African American or other	18.8	21.7
Marital status		
Married	64.2	58.3
Single or other	35.8	41.8
Rank		
Enlisted	88.1 ^a	82.5
Officer or Warrant Officer	11.9	17.5
Unit component		
Active duty	17.7 ^a	34.1
National Guard	44.5	35.0
Reserve	37.7	30.9

^a Statistically significant difference between notified and non-notified groups ($p < 0.05$).

show goodness-of-fit statistic for the propensity score analysis yielded a χ^2 value of 3.13 (8 df, $p = 0.93$), indicating a good fit. Table VII shows that there were no statistically significant dif-

TABLE IV

INITIAL HEALTH SURVEY: PERCENT DISTRIBUTION OF BED DAYS, LIMITATION OF ACTIVITY, AND MEDICAL CARE UTILIZATION ATTRIBUTABLE TO ILLNESS, ACCORDING TO NOTIFICATION STATUS

Condition	Distribution (%)		<i>p</i> ^a
	Non-notified	Notified	
Bed days			
0	68.0	72.7	
1-2	19.6	18.5	
3-4	6.5	5.2	
≥5	5.9	3.6	
Not answered	—	—	0.36
Limitation of activity			
No	79.1	79.4	
Yes	20.9	20.6	
Not answered	—	—	0.93
Clinic visits			
0	38.1	43.8	
1-3	35.4	31.0	
4-6	12.5	12.4	
≥7	14.1	12.8	
Not answered	—	—	0.45
Hospitalizations			
0	93.0	91.4	
1	5.3	6.5	
2	0.7	1.6	
≥3	1.0	0.5	
Not answered	—	—	0.46
Health status			
Excellent	10.1	10.3	
Very good	21.6	20.6	
Good	38.1	38.7	
Fair	26.1	25.0	
Poor	4.1	5.4	
Not answered	—	—	0.95

Numbers of subjects in the "not answered" category are presented but are not included in the denominator in calculation of percentages.

^a Probability value from χ^2 test.

ferences between non-notified and notified subjects with respect to the rates of bed days, activity limitations, clinic visits, or hospitalizations.

Table VIII shows that there were three statistically significant differences between notified and non-notified subjects in the prevalence of selected medical conditions, i.e., other cancer, recurrent headache, and neuralgia. Only recurrent headache was reported at a higher rate among notified subjects. An additional analysis of the numbers of medical conditions (on average, approximately four conditions per person) also showed no significant difference between notified and non-notified subjects, after adjustment for the factors listed above.

Table IX shows two statistically significant associations between notification status and self-reported severe symptoms, after adjustment for confounding factors, i.e., irregular heart-beat and bruise or bleed easily. In both cases, rates were lower among notified subjects. Aside from statistical significance, the range of estimated risk ratios was fairly narrow, and there were approximately as many risk ratios above 1.0 (six risk ratios) as below 1.0 (10 risk ratios). An additional analysis of the numbers of severe symptoms (on average, four or five per person) also showed no significant differences between notified and non-

TABLE V

INITIAL HEALTH SURVEY: PREVALENCE RATES OF SELECTED SELF-REPORTED MEDICAL CONDITIONS DURING THE PAST 12 MONTHS, ACCORDING TO NOTIFICATION STATUS

Medical Condition	Rate (%)		<i>p</i> ^a
	Non-notified	Notified	
Arthritis	29.1	30.3	0.73
Lumbago	21.3	21.4	0.97
Disease of muscles/tendons	12.2	10.9	0.59
Skin cancer	3.6	4.5	0.52
Eczema or psoriasis	10.5	9.1	0.52
Dermatitis	36.1	35.3	0.83
Disease of hair/scalp, including hair loss	21.0	19.4	0.60
Gastritis	30.7	32.1	0.68
Enteritis	12.8	8.4	0.05
Colitis	8.9	6.8	0.30
Frequent diarrhea	27.4	29.9	0.45
Other endocrine diseases	4.5	2.3	0.08
Recurrent headaches	46.8	42.0	0.20
Migraines	19.0	20.3	0.66
Neuralgia or neuritis	6.2	7.5	0.50
Diseases of genital organs	8.1	6.3	0.34
Hypertension	16.2	17.4	0.68
Tachycardia	12.7	10.4	0.33
Sinus trouble	47.6	48.1	0.89
Bronchitis	14.6	12.4	0.39
Asthma	7.8	6.1	0.35
Other lung condition	7.2	6.1	0.53

Subjects in the "not answered" category are not included in the denominator in calculation of percentages. Medical conditions with <10 responding "yes" have been omitted.

^a Probability value from χ^2 test.

notified subjects, after adjustment for confounding factors. The data on post-traumatic stress disorder showed no statistically significant difference between notified and non-notified subjects (adjusted risk ratio, 1.05; 95% confidence interval, 0.604–1.826).

Discussion

The existence of baseline health survey data on a representative national sample of Gulf War veterans presented an opportunity to look at the possible effects of notification on health. The fact that the baseline health survey data were collected before notification and therefore were not subject to self-report biases is a clear advantage of this study. The requirement to conduct the health resurvey using the identical instrument, which allowed us to measure postnotification health status but also limited the scope of the resurvey, has advantages and disadvantages.

In general, response rates for the initial survey and the resurvey were quite similar, i.e., 70% (including telephone follow-up responses) in the initial health survey versus 72% in the mailed resurvey. Therefore, the total response rates for both health surveys were approximately one-half (i.e., 0.70×0.72). Compared with respondents, nonrespondents in the initial health survey³ were more likely to be younger, non-Caucasian, not married, and of enlisted rank; this is nearly the same as the nonrespondent profile we observed for the resurvey (Table I).

TABLE VI

INITIAL HEALTH SURVEY: PREVALENCE RATES OF SELF-REPORTED SEVERE SYMPTOMS DURING THE PAST 1 YEAR, ACCORDING TO NOTIFICATION STATUS

Symptom	Rate (%)		p ^a
	Non-notified	Notified	
Any headaches	21.0	20.0	0.74
Hearing loss	8.5	9.7	0.56
Wheezing	10.1	6.6	0.08
Runny nose	23.4	22.7	0.83
Mouth, teeth, or gum problems	15.6	15.1	0.85
Sore throat or hoarse voice	12.0	10.4	0.48
Trouble swallowing	2.9	6.0	0.06
Coughing	10.7	9.2	0.50
Breathing or shortness of breath	11.1	7.2	0.07
Tightness in chest	5.2	5.6	0.79
Irregular heartbeat	6.2	4.7	0.38
Back pain/spasms	21.2	22.7	0.62
Swelling of feet/ankles	3.6	4.5	0.54
General muscle aches or cramps	12.1	13.3	0.62
Joint aches or pain	22.4	18.7	0.22
Numbness in hands/feet	12.4	12.4	0.99
Swelling in any joints	6.5	7.4	0.62
Bruise or bleed easily	3.6	3.4	0.88
Skin rash	16.2	12.6	0.16
Hair loss	6.5	6.3	0.91
Loss of balance/dizziness	4.2	5.7	0.38
Sudden loss of strength	6.9	6.1	0.67
Excessive fatigue	23.0	16.2	0.02
Fatigue >24 hours after exertion	10.8	8.8	0.36
Nausea	4.9	4.9	0.96
Vomiting	3.2	2.0	0.30
Stomach or abdominal pain	9.8	10.3	0.81
Reflux, heartburn, or indigestion	14.6	11.9	0.28
Diarrhea	8.4	9.0	0.80
Constipation	4.6	2.0	0.05
Frequent/painful urination	4.2	4.5	0.84
Impotence or other sexual problems	4.9	3.9	0.48
Fever or chills	4.2	4.7	0.75
Sweating not attributable to exercise	4.6	6.3	0.30
Sleep difficulty	18.7	13.9	0.08
Sleepiness during daytime	12.6	11.2	0.55
Awaken tired or worn out	17.4	14.6	0.29
Anxious, irritable, or upset	19.2	17.8	0.61
Been depressed or blue	14.6	15.1	0.86
Tremor/shaking	3.6	2.9	0.62
Wound slow to heal	3.9	3.2	0.58
Speech difficulty	2.6	1.4	0.21
Concentration/memory problems	15.4	13.5	0.49
Sensitive to chemicals	5.8	6.8	0.61

Subjects in the "not answered" category are not included in the denominator in calculation of percentages. Medical conditions with <10 responding "yes" have been omitted.

^a Probability value from χ^2 test.

A comparison of items concerning exposures while in the Gulf, for which reporting should have been identical in the initial survey and the resurvey, showed reasonable rates of agreement for most items, with only one statistically significant difference in κ levels between notified and non-notified subjects (Table II). It should be noted, however, that others found evidence of the unreliability of self-reports of similar factors.⁵ No-

TABLE VII

RESURVEY: ADJUSTED RISK RATIO ESTIMATES FOR ASSOCIATION BETWEEN NOTIFICATION AND BED DAYS, ACTIVITY LIMITATION, AND MEDICAL CARE UTILIZATION

Outcome	Adjusted Risk Ratio ^a
Bed days (any versus none)	1.07 (0.87-1.31)
Activity limitations (yes/no)	1.11 (0.88-1.39)
Clinic visits (any versus none)	1.01 (0.82-1.24)
Hospital visits (any versus none)	0.91 (0.70-1.18)

^a Adjusted for exposure status, initial health survey response, age, race, gender, marital status, rank, and type of duty (active duty, National Guard, or Reserve).

TABLE VIII

RESURVEY: UNADJUSTED AND ADJUSTED RISK RATIO ESTIMATES FOR ASSOCIATION BETWEEN NOTIFICATION AND SELF-REPORTED MEDICAL CONDITIONS IN THE PAST 12 MONTHS

Medical Condition	Unadjusted Risk Ratio	Adjusted Risk Ratio ^a
Arthritis	1.05	1.11 (0.89-1.38)
Lumbago	0.96	1.01 (0.79-1.29)
Diseases of muscles or tendons	0.81	0.89 (0.69-1.15)
Skin cancers	0.93	0.84 (0.55-1.28)
Other cancers	0.51	0.61 (0.38-0.97)
Eczema/psoriasis	0.80	0.71 (0.50-1.01)
Dermatitis or other skin trouble	0.99	1.01 (0.82-1.24)
Diseases of hair or scalp, including hair loss	1.06	1.20 (0.91-1.58)
Gastritis	1.02	1.06 (0.83-1.35)
Enteritis	0.89	0.95 (0.70-1.30)
Colitis	0.96	1.08 (0.76-1.55)
Frequent diarrhea	0.99	0.96 (0.75-1.24)
Diabetes mellitus	0.81	0.80 (0.49-1.30)
Other endocrine problems	0.89	1.08 (0.63-1.83)
Repeated seizures	0.77	0.70 (0.39-1.15)
Recurrent headaches	1.18	1.39 (1.12-1.73)
Migraines	1.07	1.12 (0.82-1.51)
Neuralgia or neuritis	0.67	0.60 (0.47-0.76)
Diseases of genital organs	1.08	1.16 (0.79-1.71)
Coronary disease	0.89	0.82 (0.54-1.25)
Hypertension	1.07	1.13 (0.82-1.54)
Tachycardia	0.93	1.00 (0.76-1.33)
Sinus trouble	0.97	1.03 (0.82-1.28)
Bronchitis	0.94	0.99 (0.78-1.26)
Asthma	0.86	0.96 (0.68-1.35)
Other lung condition	1.10	1.12 (0.78-1.61)

^a Adjusted for exposure status, initial health survey response, age, race, gender, marital status, rank, and type of duty (active duty, National Guard, or Reserve).

tified subjects were younger, more likely to be male, and less likely to be married than were non-notified subjects (Table III).

Tables IV to VI show that the notified and non-notified subjects had approximately the same health statuses, as measured in the initial health survey. Given the relatively large number of comparisons (71 health outcomes), it was not surprising to find one statistically significant difference, which can be attributed to the action of chance. Tables VII, VIII, and IX show that post-notification health was not adversely associated with notifica-

TABLE IX

RESURVEY: ADJUSTED RISK RATIO ESTIMATES FOR ASSOCIATION BETWEEN NOTIFICATION AND SELF-REPORTED SEVERE SYMPTOMS IN THE PAST 1 YEAR

Symptom	Unadjusted Risk Ratio	Adjusted Risk Ratio ^a
Any headaches	1.01	1.07 (0.83-1.38)
Blurred vision	0.87	0.79 (0.53-1.19)
Hearing loss	1.15	1.18 (0.82-1.69)
Wheezing	0.92	1.18 (0.81-1.71)
Runny or congested nose	0.89	0.93 (0.74-1.15)
Mouth, teeth, or gum problems	0.89	0.92 (0.71-1.19)
Sore throat or hoarse voice	0.86	0.94 (0.71-1.25)
Trouble swallowing	0.90	0.89 (0.56-1.43)
Swollen glands	0.88	0.82 (0.56-1.19)
Coughing	0.96	0.99 (0.69-1.41)
Breathing or shortness of breath	0.84	0.84 (0.61-1.17)
Tightness in chest	0.82	0.78 (0.57-1.08)
Irregular heartbeat	0.71	0.69 (0.51-0.93)
Back pain/spasms	0.90	0.90 (0.72-1.13)
Swelling of feet/ankles	1.13	1.16 (0.78-1.72)
General muscle aches or cramps	0.84	0.88 (0.69-1.12)
Joint aches or pain	0.90	0.99 (0.80-1.22)
Numbness or tingling in hands/feet	0.86	0.88 (0.70-1.11)
Swelling in any joints	1.11	1.01 (0.71-1.42)
Bruise or bleed easily	0.69	0.60 (0.41-0.88)
Skin rashes	1.02	1.11 (0.85-1.45)
Hair loss	1.06	1.03 (0.72-1.48)
Loss of balance/dizziness	0.90	0.78 (0.57-1.07)
Sudden loss of strength	0.96	1.10 (0.75-1.62)
Excessive fatigue	0.99	1.14 (0.89-1.46)
Fatigue >24 hours after exertion	0.91	1.00 (0.76-1.33)
Nausea	1.19	1.00 (0.58-1.71)
Stomach or abdominal pain	1.08	1.15 (0.80-1.64)
Reflux, heartburn, or indigestion	0.86	0.92 (0.69-1.23)
Diarrhea	1.01	1.08 (0.78-1.49)
Constipation	0.81	1.01 (0.61-1.67)
Painful urination	1.04	1.11 (0.73-1.69)
Impotence or other sexual problems	0.94	0.98 (0.72-1.34)
Fever or chills	1.14	1.19 (0.74-1.93)
Sweating not attributable to exercise	1.00	1.00 (0.70-1.43)
Sleep difficulty	0.88	0.97 (0.77-1.21)
Excessive daytime sleepiness	1.04	1.07 (0.82-1.41)
Awaken tired or worn out	0.82	0.86 (0.69-1.08)
Anxious, irritable, or upset	0.87	0.93 (0.75-1.14)
Been depressed or blue	0.83	0.83 (0.67-1.03)
Tremor/shaking	0.79	0.83 (0.57-1.20)
Concentration/memory problems	0.97	1.06 (0.81-1.39)
Sensitive to chemicals	1.21	1.34 (0.89-2.02)

^a Adjusted for exposure status, initial health survey response, age, race, gender, marital status, rank, and type of duty (active duty, National Guard, or Reserve).

tion; there were five statistically significant associations, four of which were <1.00. Given the number of tests, such a set of findings could be attributed to chance. The one significantly

elevated risk ratio among notified subjects was for recurring headaches as a medical condition ("Did you have any one of the following medical conditions: recurrent headaches?"); the corresponding association with symptoms of headache ("In the past year, have you had consistent or recurring problems with: any headaches?") was not statistically significant.

Although the health statuses of notified and non-notified, deployed, Army Gulf War veterans were very similar, as were the health statuses of potentially exposed and nonexposed, deployed, Army Gulf War veterans,¹ we must note that, in this study and our companion article, we studied only deployed Army personnel. It was important to limit our studies to deployed personnel because there are marked differences in self-reported health status between deployed and nondeployed Gulf War veterans,³ but the design of our current study did not allow us to examine health differences associated with deployment.

It is not in our purview to speculate after the fact regarding what kind of notification letters should have been sent, if any. Nonetheless, it is clear that this exercise in risk communication was undertaken in circumstances that were far from optimal. First, exposure status was uncertain, as reflected in the fact that three notification efforts were undertaken sequentially, and some still doubt the accuracy of the exposure model.⁶ In addition, there were no known health effects thought to have been associated with potential exposure. Although we might have expected that heightened perception of possible risk in the notified group would have led to higher self-reported rates of illness,⁷ this was not the case. Perhaps this was attributable to the fact that media coverage had already increased awareness of the issue,⁸ or perhaps it simply reflects a well-done job of risk communication. It is important to note that our findings contradict the prevailing notion that perceived exposure to chemical warfare agents should be considered an important cause of morbidity among Gulf War veterans.⁹

In summary, there were few adverse health effects associated with notification regarding potential exposure to nerve agents, a finding that contradicts the prevailing view. Our study was limited to deployed Army personnel, however, and these results may not be generalizable to other personnel. Those who may be planning future notification efforts may nonetheless take some comfort in the fact that there were few adverse effects seen in this study.

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